CURING HAY IN THE STACK

REA Demonstrations Indicate Value of Field-Curing Alfalfa Hay in Stack by Use of Fans Powered by Electricity

The 48-inch electrically-driven fan in the front of the stack above drove large volumes of air into the bales of hay, curing it thoroughly in 14 days. Hay was of No. 1 grade when drying was completed.

ARTIFICIAL curing of hay through the use of electrically powered blowers is rapidly becoming established as a valuable farm practice. For a steadily increasing number of farmers in the eastern States, barn hay driers are taking the weather hazard out of haymaking and producing better hay.

In western areas, however, few farmers and ranchers use barns to store hay. Free of the threat of heavy rain during haying, farmers west of Kansas City frequently leave hay in the field from 3 days to 3 weeks until it is dry enough to stack for winter use.

Unfortunately, the same fair weather that makes this practice possible also results in the production of much second- and third-grade hay of relatively low value for feeding or cash sale. Brilliant sunshine, with ultraviolet light passing through thin air, fades the hay during the drying period. This lowers carotene and vitamin A content. Hot days wilt the leaves too rapidly. This results in excessive leaf shattering in handling and high moisture content in the stems. Heavy dews and light showers greatly increase vitamin and color losses and leaf shattering. (See table on p. 14.)

If the hay can be stacked as soon as it is cut, the effect of these conditions is largely avoided. Immediate stacking becomes practical when forced air is used to dry the hay in the stack. With an electrically powered fan and a temporary electrical connection into the field, it appears that the western hay maker can get a better product by using the outdoor equivalent of the barn hay drier so popular with his neighbors farther east. In fact, stack drying could be used in more humid climates if stack covers were provided for protection from weather after curing was completed.

During the last 2 years, successful field demonstrations have been conducted in Colorado and Wyoming in artificial curing of alfalfa hay stacked within 24 hours after it was cut. Tests were made with long hay, chopped hay, and baled hay. The demonstrations were made by REA engineers in cooperation, in 1947, with Colorado A and M. College and the Poudre Valley Rural Electric Association of Fort Collins. The 1948 demonstrations were made with the San Luis Valley Electric Cooperative and the Mountain View Electric Association in Colorado and with the Wyrulec Co., an REA-financed cooperative at Lingle, Wyo., and the University of Wyoming. Methods used are described on the following three pages.

Bales were placed to form a 4 feet by 4 feet by 25 feet air duct in the center of the stack.

Drying Long Hay

Method: Hay was picked up from the windrows by a tractor-mounted buck rake, and stacked by an overshot haystacker. The stack was built over an A-shaped frame 8 feet wide at the bottom, 2 feet wide at the top, 7 feet high and 10 feet long. The stack dimensions were 22 by 22 by 14 feet when completed, but it settled 2 feet in drying. An air seal was formed by 6 feet of hay on the sides, 4 feet on the fan end of the stack and 6 feet on the opposite end. (The extra 2 feet opposite the fan were necessary to hold the air pressure.)

A 5-horsepower single-phase electric motor was used to drive a 36-inch multiblade propeller fan delivering approximately 16,000 cubic feet of air per minute. This is much more air than was needed for this small stack but the equipment was planned so that the rancher could use it on much larger stacks later. Fifteen cubic feet of air per minute per square foot of stack area is the minimum air volume recommended. The system was designed so that air pressure would be maintained at 0.75 of an inch of water (enough pressure to hold up a column of water three-fourths of an inch high.) Pressure-measuring equipment was used to check this.

Results: The estimated moisture content of this hay at stacking time was 45 percent. It required 14 days to cure it to approximately 10 percent moisture content. The fan was operated continuously during the first 5 days of this period and thereafter during daylight hours only. When cured, the hay graded U. S. No. 1, Very Leafy, Very Green Alfalfa Hay. The cured hay was found to have 50 percent of leaves by weight and 80 percent color retention.

In later demonstrations with long hay, more attention was given to obtaining an air seal at both the fan end and the opposite end of the stack. Also, the A-frame was widened at the top from 2 feet to 6 feet. This gave more uniform air penetration in the hay above the 7-foot level in the stack.

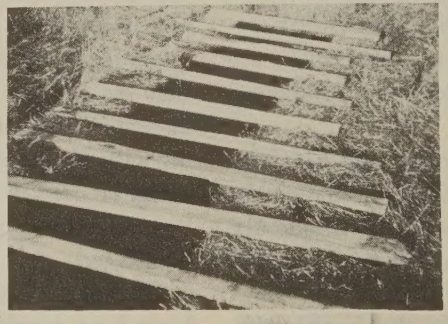
Drying Chopped Hay

Method: The frame for curing chopped hay in the stack was of the slatted floor type, and was made in the shape of a very shallow and widespread inverted V. This slatted floor was 11 feet wide by 29 feet long, and 44 inches high in the center. The stack was formed by placing two strips of wire hog fence one above the other around the sides of this floor. This confined the hay over the floor and formed a straight-sided rectangular stack. Posts at the corners and along the sides held the fence in position. The inside of the fence was lined with building paper to prevent air loss.

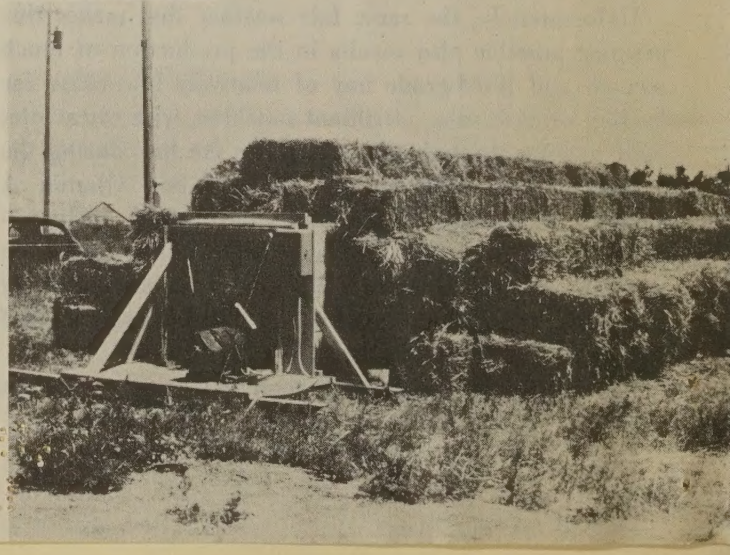
The stack was made 4 feet wider than the slatted floor, giving an air seal of 2 feet of chopped hay along each side. The stack was also made 4 feet longer than the slatted floor, allowing a 2-foot chopped hay air seal at the fan end and the same seal at the end opposite the fan. Total depth of the hay as stacked was less than 9 feet and it settled to about 8 feet. Stack dimensions were 15 by 33 by 8 feet when cured. The stack was estimated to contain about 12 tons of cured hay.

Again 15 cubic feet of air per minute per square foot of stack area was considered the minimum volume of air needed for quick and satisfactory curing. A 5-horsepower single-phase motor and a 36-inch multiblade propeller fan were used to force air into the stack through the slatted floor.

Results: The demonstration with chopped hay was hampered by unpreventable delays for machinery repair. As a result, cutting, raking, field chopping from windrows and stacking occupied 3 days. Even under these conditions, quite satisfactory cured hay was produced. For best results, it appears that the hay should be cut and stacked the same day if the mois-



Two-inch planks placed over the open central duct formed by the bales permitted sealing the duct with layers of bales.



Partially completed stack of bales. Note that central duct is closed over and sealed.

ture content can be reduced to 45 percent or less in the swath by early afternoon.

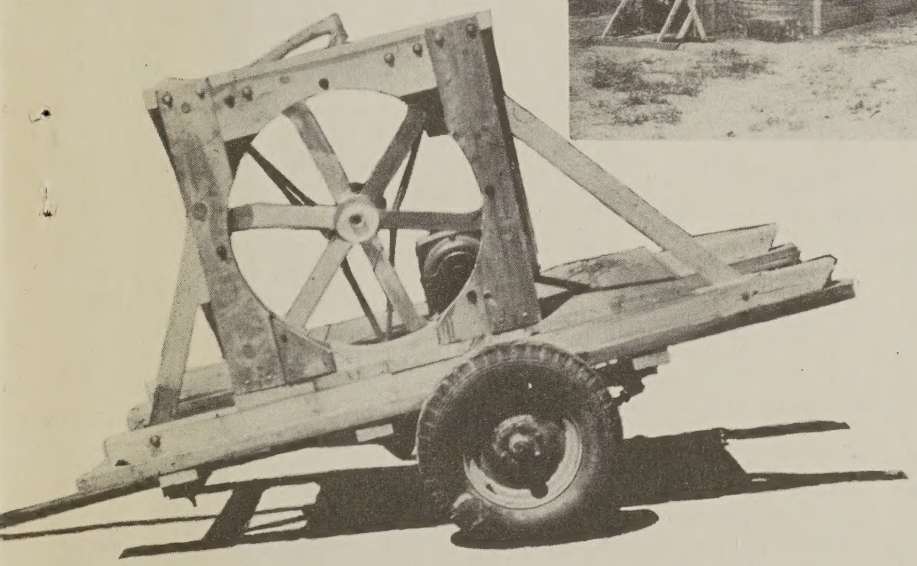
Drying Baled Hay

Method: The outstanding demonstration test was made by artificial drying of a 35-ton stack of *baled hay*. The hay was cut in the morning and raked when the moisture content was below 45 percent. Baling started at once, using a field pickup baler.

The stack was started when the first load of bales was completed. The stack was formed in the usual manner for stacking baled hay with a few exceptions. The first layer of bales was placed on edge to prevent the metal bale ties from rusting and breaking in handling when the stack was fed out. All other layers were placed flat. Since air was to be forced into the stack the bales were placed so that a central air space 4 feet by 4 feet by 25 feet was left down the center of the stack at ground level. Five rows of bales placed lengthwise were laid on each side of the center duct. This made a stack 16 feet wide, the length being about 34 feet. Each row was staggered a half bale length to break the joints between bales and to prevent excessive loss of air through the cracks between bales.

When three layers of bales had been placed, the duct was approximately 4 feet high. Two-inch by 6-inch planks were then laid on the bales across the duct. This permitted the placing of bales over the duct to close it and form the air seal. To close the duct at the stack end opposite the fan, eight staggered rows of bales were placed across the stack in the same manner as along the sides of the duct. This sealed the duct, forcing the air to escape through the cracks between bales.

At right, stack of chopped hay ready to be cured. Side walls of stack are formed by two widths of paper-covered hog fence. Below, portable multiblade drier fan mounted on trailer to move from farm to farm.



Space between bales was approximately 1 inch. Since the bale rows were staggered the air could not pass directly out of the stack but followed a zig-zag path. This enabled the fan to maintain the necessary pressure for even distribution of air. At the same time the air could escape in sufficient volume to remove the heat and moisture, thus curing the hay. After the third layer, each layer of bales was drawn in a half bale width along the sides. This permitted the stack to be topped out when it was 11 bales high.

To prevent air loss between the fan and stack a wooden duct 4 feet by 4 feet by 8 feet long was inserted in the stack at the fan end. A canvas collar 2 feet wide was tacked around the fan frame and on the inside of the wooden duct. This prevented any loss of air at the fan end. Air pressure of 1¼ to 1½ inches of water was maintained throughout the entire curing period when the fan was operated.

The fan was started when the duct was covered with one layer of bales, and operated continuously for a week. It was then operated for 7 more days during daylight hours only.

A 7½-horsepower single-phase motor was used to drive a 48-inch multiblade fan. Approximately 23,000 cubic feet of air per minute at a pressure of 1½ inches of water was blown through the stack. A minimum of 20 cubic feet of air per square foot of stack area is recommended as the minimum for safe curing of baled hay. On this basis, the equipment used in this demonstration could have been used for a stack containing up to 70 tons of hay.

Curing observations: The flow of air from the main duct through the cracks between bales was carefully observed during the test. This check indicated that air was escaping from all the cracks with approximately the same velocity and that no hot air, indicating hot spots in the stack, was present at any point. Pressure measuring equipment indicated that a pressure of 1½ inches of water was maintained for one week inside the air chamber and then dropped to 1¼ inches—a loss of only a quarter inch of pressure due to bale shrinkage.

As the air passed through the stack it picked up the heat formed and removed the moisture from the outside layers of each bale. The moisture and any heat in the bale apparently travelled by diffusion and conduction from the inside to the outside of each bale where the air picked up and removed both. The fan was first started 2 hours after stacking began, and the escaping air was very hot, reaching temperatures as high as 120° F. After the first 2 hours, temperatures of escaping air were always 4° to 12° less than the temperature entering the stack at the fan. In fact, the air felt cool to the hands when inserted between the bales.

(*Continued on next page*)

This temperature difference indicates that the heat in the stack was removed as fast as it formed. It also means that the air was evaporating moisture, which resulted in lowering the temperature of the air as it passes through the stack. When the hay inside the stack felt cold to the hand it was a sure sign that curing was progressing. When intake and escaping air were of equal temperature it indicated the hay in the stack was practically cured. Since the outside layer of bales is always last to dry, the fan was operated until those bales appeared to be dry and no heat was indicated inside them.

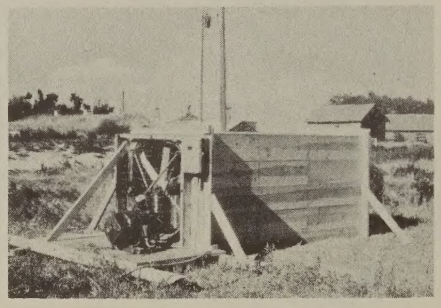
Results: At the end of 14 days, the baled hay graded U. S. No. 1 Very Green Alfalfa Hay. It fell a few percentage points short of grading Very Leafy, but this was the result of advanced maturity at cutting time. Following is a chemical analysis and grading summary for the cured baled hay:

	Percent
Moisture content	9.5
Leaves by weight	45
Color retained	78
Carotene retained	34.4
Ash	9.18
Phosphorus	.605
Calcium	2.35
Ether extract	3.83
Crude fiber	27.74
Crude protein	16.65
Nitrogen-free extract	36.12

Note.—Moisture content shown above was for stack-cured hay. The chemical analysis is based on air-dry weight averaging 6.49 percent moisture.

Precautions

A few precautions had to be taken in this new process. The first was to see that the moisture content of the hay was below 50 percent when raking started. The second was to place the hay uniformly over and around the air chamber frames to form an air seal that would not permit loss of air pressure at a thinly covered spot. With full length or chopped hay, as little tramping as possible was done; but what had to be done was made as uniform as possible. The third precaution was to examine the stacks to see that the air was escaping uniformly from the stack and was cool at all points. If too much air escapes at one place, the operator can enter the air chamber by stopping the motor and moving the fan. Canvas or grain sacks can then be placed over the corresponding surface inside the air chamber where the pressure loss is found on the out-



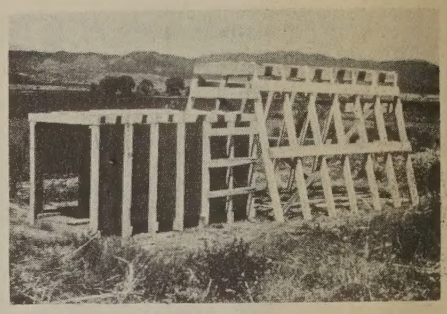
Fan mounting showing the wooden duct inserted into the baled hay stack.

side of the stack. The canvas or sacks retard the air at the thinly covered spot, forcing the air to pass out through the other parts of the stack.

Power Consumption

The amount of power consumed in stack drying will depend on the moisture content of the hay when stacked and when drying is completed; the method of making hay, i. e. long hay, chopped, or baled hay, and the climatic conditions such as air humidity and temperature during the curing period. The drier and hotter the weather, the faster the hay will cure. Rapid curing is necessary for the highest quality and feed value when artificial curing is done.

Power consumption can be expected to vary from 40 to 100 kilowatt-hours per cured ton. In the demonstrations described, the maximum power required was 87 kilowatt-hours per cured ton for the chopped loose hay. In this case, the demonstrators were of the opinion that curing was accomplished with about 600 kilowatt-hours, or 50 kilowatt-hours per ton, and that the rancher was overcautious in continuing fan operation. The baled hay required only 42 hours per cured ton, but this record was unusual, since baled hay curing would generally require more electric power per ton than long or chopped hay.



Below, the "A" frame with wide top for curing full length hay in the stack.

Hay Making and Curing Equipment

Field equipment ordinarily used for cutting, raking, gathering, and storing hay may be used with few, if any, changes for stack drying.

PERCENTAGE FEED LOSS BY LEAF SHATTERING FROM ALFALFA HAY

Hay in swath to make 1 cured ton (lbs.)	Percent leaves in alfalfa	Weight of leaves per ton of hay (lbs.)	Weight of stems per ton of hay (lbs.)	Weight of leaves lost per ton gathered (lbs.)	**Percent total feed value left in field
2,000	*50%	1,000	1,000	000	000
2,400	40%	800	1,200	400	25%
2,800	30%	600	1,400	800	42.8%
3,200	20%	400	1,600	1,200	56.25%

*Assuming 50 percent of the hay weight is in the the leaves as hay stands in field.
**75 percent of the feed value of alfalfa is in the leaves and few, if any, stems are lost even when leaves shatter badly.

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